ASSESSMENT OF S&E SUGAR CROPS RESEARCH PROGRA
BY
DARRELL F. COLE
JOINT PLANNING AND EVALUATION
STAFF PAPER SERIES NUMBER 81-PP-07
JULY 1981

Joint Planning and Evaluation

Staff Paper

Full

United States Department of Agriculture
Science and Education Administration
Washington, D.C. 20250

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The views expressed here are those of the author and do not necessarily reflect the position of the Science and Education or the United States Department of Agriculture.

Executive Summary

Sucrose consumption per capita in the United States decreased and corn sweetener consumption increased in the decade of the 1970's. Decreased per capita consumption more than offset the population increase, resulting in less total sucrose consumed in 1980 than in 1970. Domestic production of sucrose has historically provided 40-50% of the U.S. sweetener market. The balance has been imported from sugar cane producing countries. Several sugarbeet and sugarcane processing facilities in the United States were closed in the 1970's.

Use of corn sweeteners, price fluctuations, processing cost, increased demand for sweeteners, use of noncaloric sweeteners, and potential alcohol production from sugar crops were identified as factors that would impact upon the future of the domestic sugar industry in the next decade.

Goals of the Science and Education (S&E) agencies sugar crop research programs were identified as 1) increase yield per acre and processing quality, 2) reduce losses to pest, 3) reduce losses during harvest and storage, 4) increase crop tolerance to environmental stresses, 5) collect, evaluate, utilize and preserve germplasm, 6) develop fundamental knowledge, and 7) improve cultural practices.

S&E agencies have a major commitment to the sugar crops research program in both dollars ($11 million in FY 78) and scientists (over 100 in FY 78). Expressed in deflated dollars, S&E funds for sugar crops remained constant, during the last decade, whereas, dollar commitments for soybeans tripled.

S&E agencies sugar crops research programs have emphasized crop production with minor emphasis on reducing postharvest losses prior to processing. Research on processing technology has been limited.

The domestic sucrose industry faces an uncertain future and will probably continue to decline in size during the next 10 years as sucrose consumption decreases and corn sweetener consumption increases. The decline in the domestic sugar industry suggest that S&E agencies should prepare for a redirection of resources in some production areas, consolidated research efforts in other locations, and eliminate duplicate programs between State and Federal laboratories.

An ad hoc panel of scientists and administrators of S&E agencies should be established to set future goals and objectives of the S&E agencies research programs to meet the needs of the changing domestic sugar industry.

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SCIENCE AND EDUCATION SUGAR CROPS RESEARCH PROGRAM

Introduction

The manufacture of sugar from sugarcane first occurred in India around 400 B.C., and sugar was one of the first commodities shipped from the New World colonies to Europe (2)*. Either cane or beet sugar has contributed to the economic development of most nations of the world. In 1979 the United States imported 5 million tons of sugar which was approximately 50 percent of U.S. consumption (15). Several agricultural commodities are utilized in the caloric sweetener market: sucrose from sugarcane and sugarbeets; sirups from corn, sweet sorghum, sugarcane and maple trees; and honey. Sucrose and corn sirups are the major caloric sweeteners consumed.

Production and use of noncaloric sweeteners, primarily saccharin, is of minor importance to the total U.S. and world sweetener demand. Aspartame was recently cleared by the Food and Drug Administration for use as a sugar substitute.

Prior to 1974, the U.S. Sugar Act regulated sucrose supply and price in the United States (3). All major developed countries of the world have governmental programs designed to regulate sugar supplies and price. Sugar is regarded as a necessity by consumers in several countries; hence an abundant and reliable source is needed. The survival of the United States sucrose industry is a vital concern to producers and consumers (11).

Between 1970 and 1980, annual consumption of caloric sweeteners in the United States increased from 123 to 127 lb per capita (15). However, per capita consumption of sucrose decreased from 102 to 85 lb and per capita consumption

*Number in parenthesis refer to references.

of corn sirups increased from 19 to 41 lb. Consumption of other sirups and honey remained fairly constant during the same period. Noncaloric sweetener annual consumption (saccharin) increased from 5.8 to 7.1 lb (sucrose equivalent).

Sugarcane production areas are concentrated in Florida, Hawaii, Louisiana, and Texas. Sugarbeets are grown in Arizona, California, Colorado, Kansas, Idaho, Michigan, Minnesota, Montana, New Mexico, North Dakota, Ohio, Oregon, Texas, Utah, and Wyoming. Estimated acreages for mainland sugarcane and for sugarbeets in 1980 were 610,000 and 1,200,000 acres, respectively. Estimated acreage for Hawaiian cane in 1980 was 100,000 acres. Average yield of sugarcane per acre has remained static since 1930, whereas yield of sugarbeets has almost doubled during the same period (Fig. 1). Yields of sugar per acre have followed the same trend as the corresponding yields of sugarcane and sugarbeets (Fig. 2).

Average yields in 1979 were 2.6, 2.8 and 10.4 tons of sugar per acre for sugarbeet, mainland sugarcane and Hawaiian sugarcane, respectively. Sugar produced from sugarbeets, mainland sugarcane, and Hawaiian sugarcane accounted fro 51.3, 19.0, and 29.8%, respectively, of the total U.S. production of 5.6 billion tons in 1979.

ISSUES AFFECTING SUGAR CROP PRODUCTION

1. Use of Corn Sweeteners:

In the United States, use of high fructose corn sirup (HFCS) has increased at a rapid rate since its introduction in the late 1960's (15). Demand has exceeded supply, and HFCS costs less (on a dry weight basis) than sucrose. HFCS can be utilized in most processes which are not affected by its high moisture content (13).

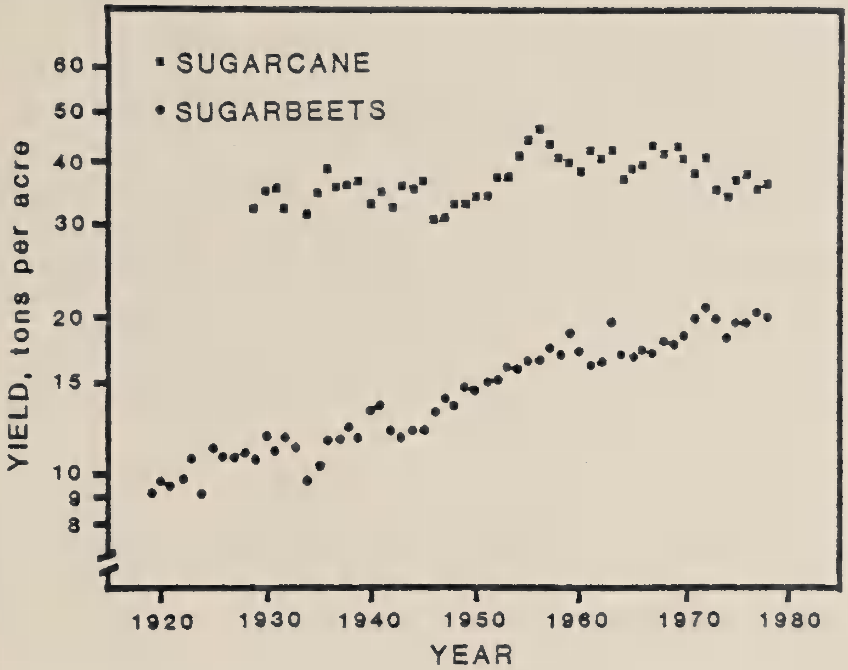

Fig 1. Average yields of sugarcane (including Hawaii) and sugarbeets in the United States. Source: Agricultural Statistics, 1980 and earlier editions, USDA.

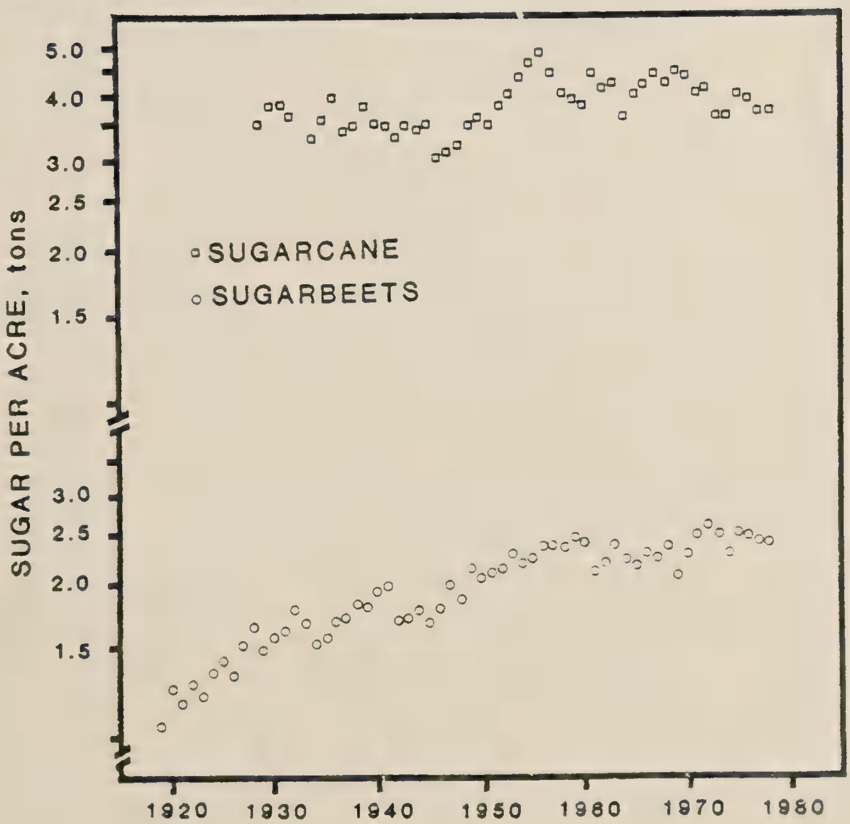

Fig. 2. Average sugar per acre of sugarcane (including Hawaii) and sugarbeets in the United States. Source: Agricultural Statistics, 1980 and earlier editions, USDA.

The soft drink industry accounts for 25% of the sweetener market. Several of the major bottlers are using HFCS in their products. HFCS will replace an even larger portion of the U.S. sucrose market as new corn processing facilities are completed. In 1980, corn sweeteners accounted for 33% of the caloric sweeteners consumed in the United States. Demand for corn sweeteners will probably reach 50% of the total caloric market by 1985 (16). Corn processors can store their raw material and process on a year-round basis, whereas mainland sugarcane and sugarbeet processors can process for a maximum of only 5-6 months per year. In addition to sweeteners, corn processors sell several other high value products such as corn oil and a protein feed supplement. If corn sweeteners would substitute for sucrose in all products, U.S. sweetener needs could be met with 6 million acres of corn. Corn was grown on 71 million acres in 1979.

As corn sweetener use increases, sucrose imports or domestic production will be significantly affected (8). Without a governmental program which regulates the amount of sucrose imports, corn sweeteners will probably affect domestic production more than the import market. Several countries provide subsidies to their domestic programs in order to obtain hard currency. The cost of production (energy, labor, and capital) is higher in the United States than in other countries. The sugarbeet industry may be affected more than the mainland cane industry because of the higher energy cost for sugarbeet processing with today's technology. The Hawaiian sugarcane industry will not be affected as severely as the mainland industry because of higher yields and the ability to process sugarcane the entire year.

If fructose and/or a mixture of glucose and fructose from corn can be crystallized economically, it will probably have a severe impact on the sucrose market (8).

2. Price Fluctuations:

Prior to 1974 the U.S. Sugar Act regulated sucrose supply and price (3). After the expiration of the Sugar Act in 1974, sucrose prices rose to record levels in 1974-75 (Fig. 3) and then declined during the late 1970's to levels that were detrimental to the domestic industry. For example, 14 sugarbeet factories ceased operations and 18 cane mills closed between 1975-1979 (5). U and I Sugar Company completely ceased processing sugarbeets in the Pacific Northwest. Their closures represent a permanent loss in processing capacity. A processing plant was moved from New York to Minnesota and reopened with major modification, but there has not been a sucessful reopening of a sugar mill or factory in the United States once the units were closed. States that ceased growing sugar crops during the 1970's are the States of Iowa, Maine, and Washington. Other producing states reduced their acreages as factories closed. The Red River Valley of North Dakota and Minnesota, Texas, and Florida are the only areas that increased sugar crop acreages during the last decade.

Price fluctuations were associated with the closure of processing plants in the United States. Other factors were 1) increased energy cost for transportation and processing, 2) need for plant modernization to meet environmental standards, 3) increased competition from nonsucrose sweeteners, 4) processing plants that were obsolete and inefficient, and 5) lack of major breakthroughs in processing technology. The basic processing technology utilized in the sugarbeet industry was developed over 100 years ago (12). Advances in agricultural production have outpaced improvements in the processing technology. Extraction efficiency has generally declined in the sugarbeet industry since 1950 (Fig. 4). Some industry personnel believe that current processing technology is obsolete, and that

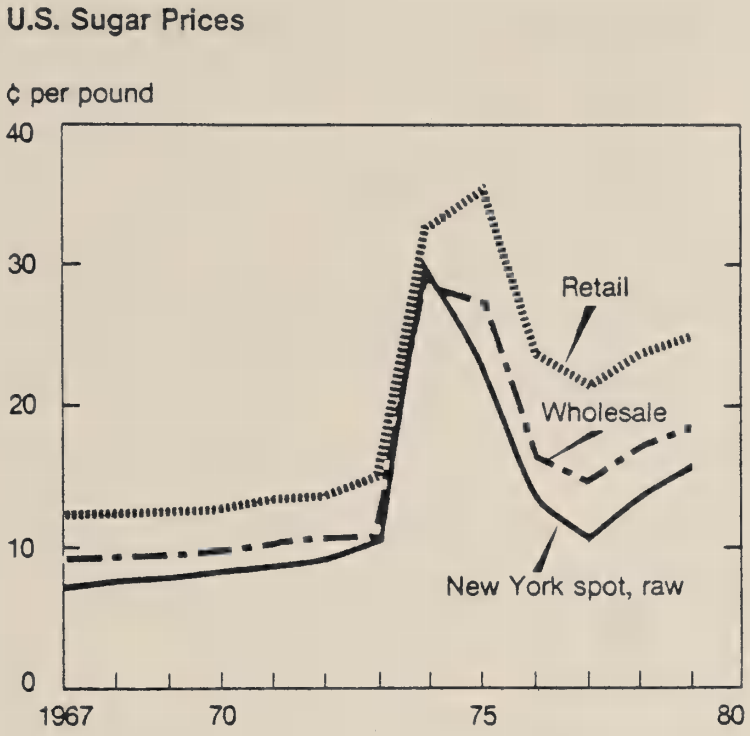

Fig. 3. U.S. sugar prices. Source: 1980 Handbook of Agricultural Charts, USDA.

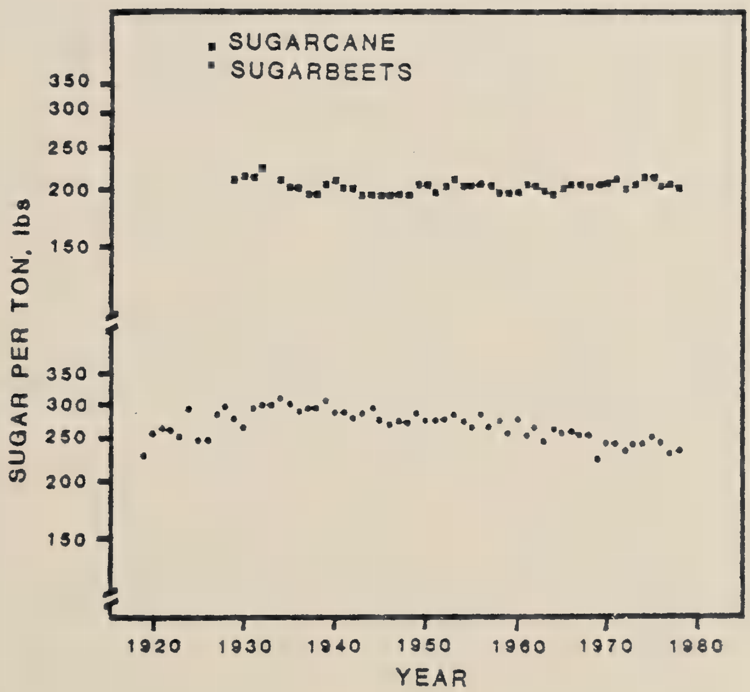

Fig. 4. Yield of sugar per ton of sugarcane (raw basis) and sugarbeets (refined basis) in the United States. Source: Agricultural Statistics, 1980 and earlier editions, USDA.

before new factories are built, a major breakthrough in processing technology will be needed to reduce energy requirements, reduce processing cost, and increase extraction efficiency.

3. Processing Cost:

The energy cost associated with production and processing has increased more for the sugarbeet industry than for the sugarcane industry. Bagasse (cane fibers) provides a major portion of the energy required for processing sugarcane. The sugarbeet industry uses either coal, natural gas, or petroleum products for factory operation. Drying the sugarbeet pulp consumes 25-30% of the energy required in the processing factory. Drying is necessary so that the by-product can be stored and shipped for use as livestock feed. Transportation costs of sugarbeets and sugarcane to the processing facilities have increased dramatically since 1973, when petroleum cost began to escalate.

4. Increased Demand for Sweeteners:

While the U.S. per capita consumption of sucrose declined in the 1970's, world demand increased because of increased population and increased per capita consumption. The U.S. per capita consumption of sucrose is double the world average. Projected consumptions (Table 1) indicate that sugar crop acreage will be expanded by the year 2000, assuming that per capita consumption of sucrose, HFCS, and sucrose imports remain at 1979 levels. The data (Table 1) are based on 1980 consumption levels and on the U.S. Census Bureau projections for U.S. and world populations in the next two decades. The data suggest that as the world population increases, the U.S. share of the world sucrose market will decline. Because the United States imports 50 percent of its sucrose supply without trade agreements, and because sucrose production cannot be increased

Table 1. Projected Sucrose Consumption, Ratio of U.S. to World Consumption and Projected Changes in Acreage for the U.S. and World Populations During the Next 20 Years.

	Consumption			Projected Acreage Increase (1)	
Year	United States	World	Ratio	United States	World
	Tons, Millions		%	Acres, 1,000	
1980	9.4 (2)	98.9 (3)	9.5	--	--
1990	10.4 (2)	117.5 (3)	8.8	385 (2)	7,150 (3)
2000	11.1 (2)	139.7 (3)	7.9	654 (2)	15,692 (3)
2000	11.1 (2)	158.8 (4)	6.9	--	23,038 (4)
2000	11.1 (2)	238.1 (5)	4.7	--	51,555 (5)
2000	8.5 (6)	--	--	-364	--

(1) based on 2.6 tons of refined sugar/acre for sugarbeet and mainland sugarcane
(2) based on 90 lb/capita
(3) based on 44 lb/capita
(4) based on 50 lb/capita
(5) based on 75 lb/capita
(6) based on 65 lb/capita, 50% of per capita sweetener consumption of 130 lb

quickly, demand may keep sucrose prices at relatively high levels in the near future. New processing facilities require major expenditures of capital for investments and existing facilities are operating at full capacity.

5. Use of Noncaloric Sweeteners:

The use of noncaloric sweeteners will continue to increase and may substantially affect the sucrose or corn sweetener market. Saccharin has been banned by the U.S. Food and Drug Administration, however, Congress passed a bill to extend the moratorium.

Aspartame has received clearance by the Food and Drug Administration (FDA) for use as a sugar substitute. Its effect on the market is not currently known, but it is expected to be used in some products. It won't be used in soft drinks under the clearance issued by FDA.

The artificial sweetener that has been developed from grapefruit may be on the market in the future. Its effect on the sweetener market is not known, but may be the same as that of saccharin or possibly HFCS on the sucrose market.

6. Potential Alcohol Production:

Sugar crops have been recognized as a potential source of biomass in a renewable energy program. Potential alcohol yield per acre is greater for sugar crops than for corn (1). However, some limitations that affect their use concern: 1) their adaptibility to only certain growing areas, 2) postharvest storage and length of processing period, 3) cost of production, and 4) cost of processing.

Sugarcane is adapted to the extreme Southeastern and South Central U.S. Sugarbeets are adapted to the arid West with irrigation, Ohio and Michigan, and the northern Great Plains. The Corn Belt and the humid Southeast are not suitable for production of current sugarbeet cultivars because of their disease susceptibility.

Sweet sorghum will grow throughout the Southeastern U.S. and into portions of the Corn Belt. The availability of any or a combination of sugar crops on a year-round basis is probably limited to sugarbeets in California with long distance transportation. Sugarcane and sweet sorghum could possibly be used together in Florida. Therefore, additional sources of fermentables are needed to maintain an alcohol plant on a year-round operation.

The length of the processing campaign for alcohol in most areas where sugarbeets are grown would be similar to that for sugar production. The maximum processing period would be September to March in the extreme northern climates and for shorter periods in other growing areas. Sugarbeet production in some growing areas might be supplemented with sweet sorghum production.

In the southern United States, sweet sorghum offers the greatest potential for alcohol production. The processing period could last 3 months if planting dates and cultivars with different maturity dates are appropriately selected. In some areas sugarcane could be used to extend the period by one to two months. Sugarcane and sweet sorghum yield more ethanol per acre than all other currently adapted crops, and the fiber can be used to supply a large portion, if not all, of the energy for processing. At present yields and costs of production, alcohol from sugar crops may be limited if economic profit is the primary incentive for production.

Goals and Objectives of S&E Sugar Crops Research Program

Goal A. Increase yield and processing quality.

Objectives:
1. Increased sugar yield per acre by breeding improved cultivars or parental lines.
2. Reduce nonsucrose components of processing juices by breeding improved cultivars or parental lines.
3. Develop improved cultural practices that increase sugar yield and minimizes nonsucrose components of processing juices.

Goal B. Reduce losses to pests.

Objectives:
1. Develop resistance to economically important insects.
2. Develop resistance to economically important plant diseases.
3. Improve chemical control of weeds.
4. Improve cultural practices to control insects, plant diseases, and weeds.
5. Improve biological control of insects, plant diseases, and weeds.

Goal C. Reduce losses during harvest and storage.

Objectives.
1. Improve harvesting procedures to eliminate dirt and trash.
2. Reduce mechanical damage.
3. Improve postharvest handling and storage systems.
4. Develop cultural practices that minimize harvest and storage losses.

Goal D. Increase tolerance to environmental stresses.

Objectives. 1. Improve irrigation and/or drainage techniques to increase sugar yield.

2. Improve cold tolerance.

3. Improve salt tolerance.

Goal E. Collect, evaluate, utilize and preserve germplasm.

Objectives: 1. Coordinate with and assist appropriate organizations in collection of sugar crop germplasm.

2. Evaluate the collections for pest resistance and agronomic characteristics.

3. Develop methods for utilization, preservation and distribution of the germplasm collections.

Goal F. Development of fundamental knowledge.

Objectives: 1. Develop an understanding of host-pest resistance mechanisms.

2. Develop an understanding of sucrose transport and storage at the cellular level.

3. Develop an understanding of photosynthate partitioning between plant growth and storage of sucrose.

Goal G. Improve cultural practices.

Objectives. 1. Improve tillage practices to minimize soil and water losses.

2. Improve recommendations for fertility and water management.

3. Improve recommendations for date of planting, plant population and other agronomic practices.

4. Reduce energy utilization in crop production.

Operational plans for the S&E goals and objectives are developed by the individual agencies. The missions of the Agricultural Research Service (ARS) locations involved in the sugar crop research program are summarized in Appendix A. A list of Current Research Information System (CRIS) projects for the State Agricultural Experiment Stations (SAES) that reported progress in 1978 or 1979 and have termination dates in 1980 or later are summarized in Appendix B. The projects listed for SAES's are directly related to the sugar crops program. SAES's also have CRIS units that indirectly relate to sugar crop programs but are not shown in Appendix B.

The SAES's have concentrated on agronomic production practices such as soil testing, pest control, irrigation, and tillage, while ARS has been the lead group in breeding and postharvest storage for sugarbeets. None of the SAES's have a sugarbeet breeding program. Cooperation between SAES's and ARS has strengthened the total sugar crops research program.

Florida, Louisiana, and Puerto Rico have sugarcane breeding programs and ARS has sugarcane breeding programs in Canal Point, FL, and Houma, LA. The ARS and SAES's research programs in sugarcane overlap in several agronomic areas, e.g. breeding and weed, insect, and disease control. The Audubon Sugar Institute at Louisiana State University is involved in sugarcane and sweet sorghum processing research. ARS cooperates in a sugarcane refining project at the Southern Regional Research Center funded by private industry.

Sugar crop extension programs are unique in some aspects. Sugarbeet processors maintain a field staff of agronomists who serve as a liaison between the company and growers. The fieldmen are knowledgeable in most aspects of production and

obtain from Cooperative State Extension Services (CSES) both information and recommendations based on Federal and State research. Demonstration and in-service workshops are held on a regular basis with the field staff. In addition, CSES specialists work with county agents in providing demonstrations and workshops for growers. The combined personnel of CSES specialists, county agents, and fieldmen are successful in providing reliable information and educational programs.

CSES programs are effective, in part due to concentrated areas of production and the relatively small number of producers. Also, most of the producers are the better farmers in each area, and they realize the need for research and extension and are highly receptive to new concepts in crop production and protection.

The CSES program in sugarcane is closely associated with the ARS and SAES's research programs. ARS staffs participate in field days and workshps, and are available for consultation by individual growers and CSES personnel on unusual problems associated with sugarcane growth and development. The number of individual growers associated with the sugarcane industry is considerably less than the number of sugarbeet growers. For example, in Florida and Hawaii, large portions of the sugarcane acreage are controlled by a few corporate entities. This reduces the need for a large extension staff devoted entirely to sugarcane. The CSES specialist in each production area works through the county agents to assist growers.

The SAES and CSES programs in sweet sorghum and sugarcane for sirup is relatively small. The acreage (30,000 acres) is spread across the southeastern United States, usually associated with small family farm operations. County

agents provide most of the extension effort in this program. Research at the SAES's is limited because of the small acreage in each state. The ARS program is essentially the entire research effort devoted to sirup production and provides the backup information for extension.

Other Research Programs

In addition to the ARS and SAES research programs, several sugarbeet processors maintain programs on production and processing. Historically, the ARS sugarbeet breeding program developed and released germplasm and breeding lines, and these were utilized by commercial companies in developing cultivars suitable for their production areas. These new cultivars are made available to the private producers. The cultivars grown in California, however, were both developed and released by the ARS program.

The ARS programs on sugarcane and sweet sorghum develops commercial cultivars and releases them to the mainland growers. The Hawaiian Sugar Planter's Association (HSPA) has a research station which is involved in several areas of sugarcane production and processing, including breeding cultivars for Hawaiian conditons. ARS has a plant physiologist located at the HSPA Experiment Station to work with the Hawaiian industry. Also, the U.S. Sugar Corporation has a large research organization involved in sugarcane development in Florida.

Industry Organizations

Components of the sugarcane and sugarbeet industries are organized into several groups that support the S&E sugar crops program. The major sugarcane producers are organized independently, e.g. Florida Sugarcane League, American Sugarcane

League (Louisiana), Rio Grande Valley Sugar Growers (Texas), and the Hawaiian Sugar Planter's Association. The Beet Sugar Development Foundation (BSDF) comprises all of the beet processors in the United States and Canada. Also, seed companies involved in beet seed production and marketing, including some European companies, are members of the BSDF. The industry organizations support and work closely with the S&E program, and industry funds are utilized by ARS, SAES, and CSES personnel at several locations.

Sugarbeet growers are organized into local groups that are concerned about local problems such as contracts with processors, labor, etc. In many instances, the local groups support research at the local level through a checkoff system. Several of the local grower associations are members of the American Sugarbeet Growers Association headquartered in Washington, D.C.

Other industry groups headquartered in Washington, D.C. are the Sugar Refiners Association, United States Beet Sugar Association, Sugar Users Group, and the Sugar Association, Inc.

S&E Resource Allocation

Between FY 67 and FY 78 total (USDA and SAES) research funds for sugar crops remained constant when expressed in deflated dollars (Fig. 5). In contrast, research funds tripled for soybeans, increased slightly for corn, and decreased for cotton during the same period. ARS research funds for these commodities followed the same general pattern (Fig. 6). In FY 67, the USDA research funds represented 70 percent of the total spent on sugar crops, as compared with 63 percent in FY 78.

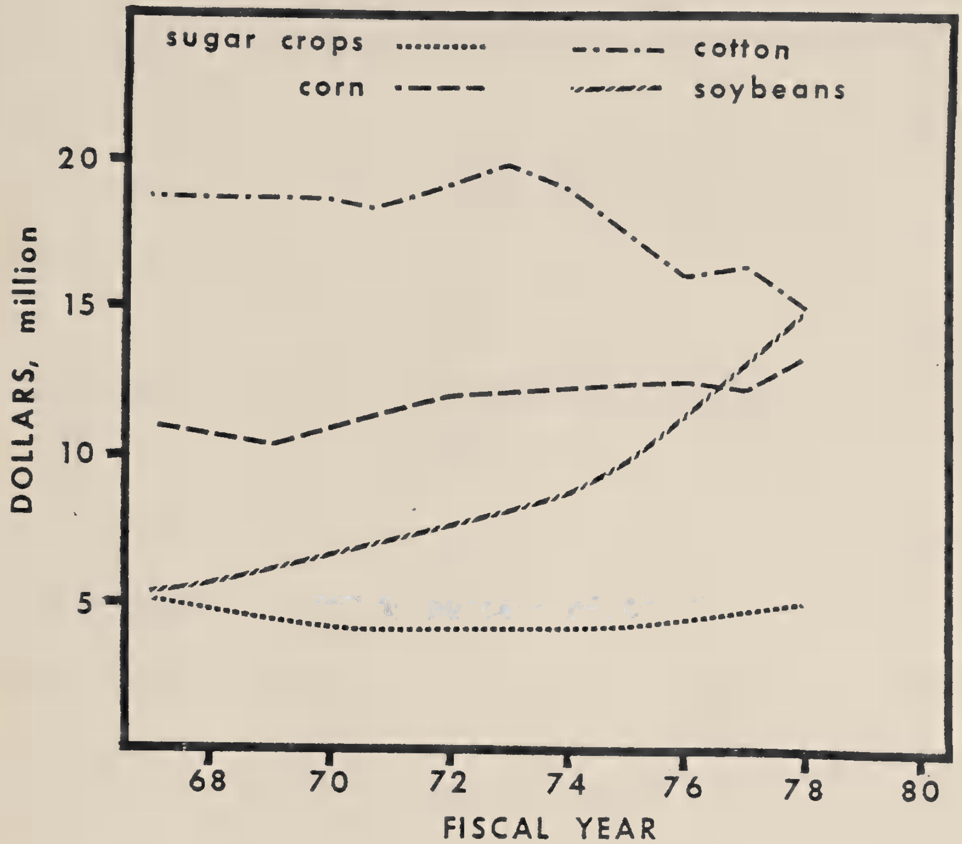

Fig. 5. Total USDA and SAES funds for research on selected commodities, as expressed in 1967 dollars. Source: Inventory of Agricultural Research FY 1978 and earlier editions, USDA, ARM-H-5.

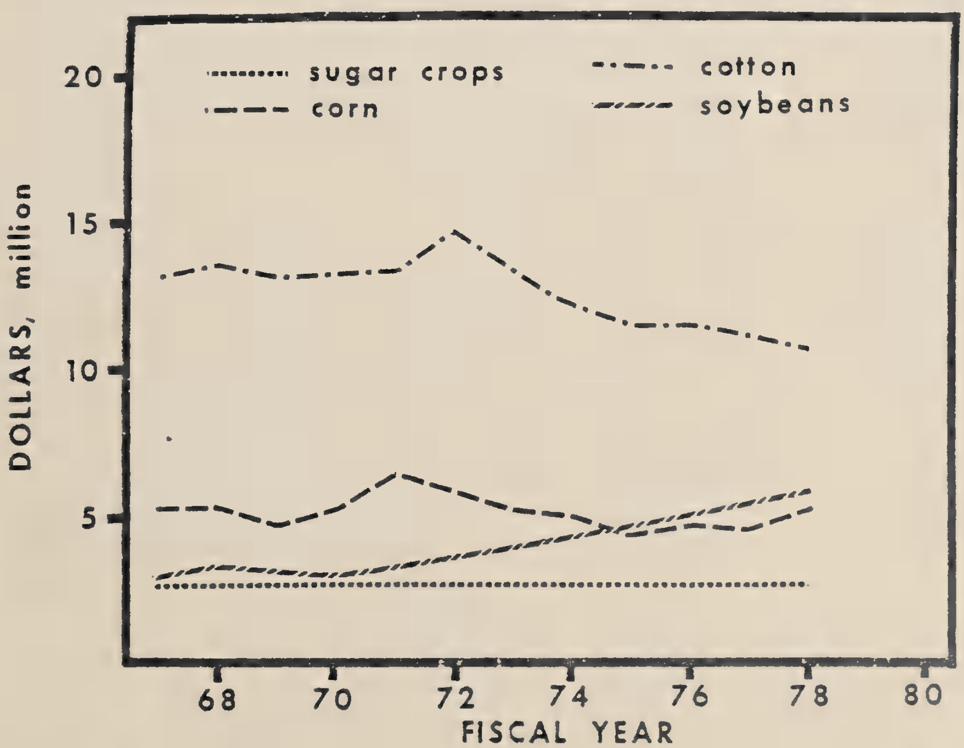

Fig. 6. USDA funds for research on selected commodities, as expressed in 1967 dollars. Source: Inventory of Agricultural Research FY 1978 and earlier editions, USDA, ARM-H-5.

A total of $11.1 million was spent in FY 78, of which 54.5 and 45.6% were devoted to ARS and SAES programs, respectively. Cooperative State Research Service (CSRS) input to the SAES program was approximately $1.0 million, or 20 percent of the State effort in FY 78.

The expenditures for sugarbeet, sugarcane, and sweet sorghum of the total sugar crops program were 45.5, 42,2, and 10.2 percent, respectively in FY 78. Between FY 70 and FY 78 there was a loss of 16.5 scientific years (SY's) in the sugar crops programs (Table 2). Over 60 percent of the USDA and SAES SY's are devoted to two research problem areas (RPA's), Control of Diseases--Field Crops and Improving Biological Efficiency--Field Crops. The SAES's have projects in 10 RPA's that are not covered by the USDA program. In FY 78, 56 and 59.6 ARS and SAES SY's, respectively, were associated with the sugar crops research program. Approximately two-thirds of the SAES SY's were associated with sugarcane and one-third to sugarbeets whereas in ARS, approximatey one-half of the SY's were devoted to sugarcane and one-half to sugarbeets (Fig. 7). The SY's devoted to the sweet sorghum research program have remained fairly consistent between FY 70 and FY 78 (Fig. 7).

The ARS funds and SY's for the sugar crops program in FY 80 by location are shown in Table 3. Extension Service (ES) resources are not readily available for the sugar crops program which in FY 76 had 19 professional staff years related to the sugar crops program.

A report submitted to the Joint Council on Food and Agricultural Sciences indicates that over the 1979-84 time period, no major shifts are planned in the sugar crops research program with no increase in base funds (6).

Table 2. Scientific Years in USDA and SAES by Research Problem Area in FY 78 and the Change in SY's from FY 70 (1).

Research Problem Area		USDA		SAES	
			Change from		Change from
Number	Title	FY 78	FY 70	FY 78	FY 70
207	Control of Insects Affecting Field Crops	5.0	-4.2	4.4	+1.6
208	Control of Diseases - Field Crops and Range	20.3	-4.5	8.3	-2.0
209	Control of Weeds - Field Crops and Range	3.5	+0.7	3.7	-0.4
214	Protection of Plants, Animals, & Man from Pollution			0.8	+0.1
307	Improve Biological Efficiency - Field Crops	14.0	-2.9	28.5	-5.6
308	Mechanization of Field Crop Production	2.0	0	2.9	+0.8
309	Production Management Systems - Field Crops			1.3	-2.4
405	Production of Field Crops - Improved Acceptibility	4.6	-1.2	0.3	+0.3
406	New and Improved Field Crop products	3.7	+2.4	0.1	-2.4
407	New and Improved Feed, Textile, and Industrial Products	0.3	+0.3	6.0	+1.8
408	Quality Maintenance in Storing and Marketing - Field Crops	2.5	+2.5	0.4	+0.2
503	Efficiency in Marketing Agricultural Products and Product Inputs			0.5	-0.6
506	Supply, Demand, and Price Analysis - Crop and Animal			0.4	-0.9
507	Competitive Interrelationship in Agriculture			0.4	+0.2
509	Performance of Marketing Systems	0.0	-1.3		
601	Foreign Market Development			0.0	-0.3
701	Insure Food Products Free of Toxic Contaminants			0.7	+0.7
704	Home & Commercial Food Service			0.2	+0.1
708	Human Nutrition			0.4	+0.4
808	Government Programs to Balance Farm Output & Demand			0.2	0.0
901	Alleviation of Pollution and Waste Disposal			0.2	+0.2
	Total	56.0	-8.0	59.6	-8.5

(1) USDA — United States Department of Agriculture
SAES — State Agricultural Experiment Stations
FY -- fiscal year

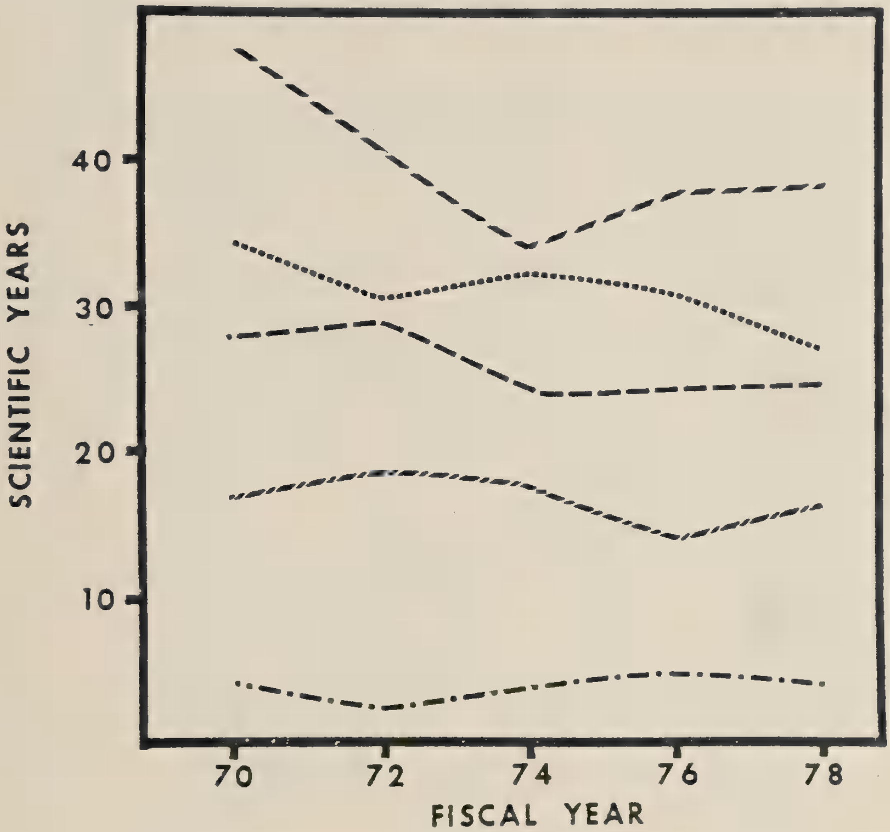

Fig. 7. USDA and SAES scientific input in sugar crops research programs for selected fiscal years.

Sugarcane: USDA ——— SAES

Sugarbeets: USDA ········ SAES

Sweet sorghum: Total USDA and SAES —·—··

Table 3. USDA - ARS Inputs into the Sugar Crops Research Program by Location for Fiscal Year 1980.

Location	National Research Program (1)	Scientific Years	Dollars
Beltsville	20090,20170,20270	3.32	535,530
East Lansing	20090	3.00	382,556
Fargo	20090	3.00	272,026
Mandan	20780	0.19	16,483
Salinas	20090,20270	7.00	866,679
Honolulu	20090	1.00	361,832
Fort Collins	20090,20280	5.00	594,684
Logan	20090,20270	4.15	517,054
Kimberly	20240	0.41	106,351
Yakima (2)	20240,20300	0.54	212,374
Prosser (2)	20280	0.57	49,938
Corvallis	20050	0.10	33,946
New Orleans	20520	1.00	90,565
Weslaco	20270,20520,20730	2.76	402,803
Stoneville	20240,20280	0.94	94,470
Meridian	20090	4.00	398,695
Houma	20090,20240,20280	10.40	1,404,212
Baton Rouge	20740	0.53	57,925
Canal Point	20090,20240	4.00	849,024
Belle Glade	20190	2.00	337,101
Sidney	20750	0.20	
		54.43	7,584,248
	TOTAL 20090	38.00	5,426,694
	All Other NRP's	16.43	2,157,554

(1) 20050 - Small grain production
20090 - Sugar crop production
20170 - Physiology and biochemistry of plants
20190 - Equipment for production and harvest
20240 - Field crops insect control
20270 - Disease and nematode control
20280 - Weed control technology
20300 - Pest control equipment
20520 - Processing field crops
20740 - Irrigation and drainage
20750 - Tillage practices
20780 - Soil fertility

(2) Will be redirected in FY '81 due to loss of sugarbeet acreage in Washington

Future Projections Concerning the Domestic Sucrose Industry

The domestic sucrose industry faces an uncertain future and will probably undergo some reductions in size during the next 10 years. Energy and other production costs (land, water, labor, capital) will continue to increase in the United States and may increase to levels that would restrict production if prices do not increase. Sugar prices are not regulated, and the U.S. price is determined by changes in the world market. World prices were volatile during the last decade and may continue to be so. Sugar may be included in the 1981 Farm Bill. If it is included, a loan rate for domestic production will be set in an attempt to stabilize prices.

Other changes will result as the corn sweeteners industry expands and continues to increase its share of the nutritive sweetener market to 50%. Coupled with an increase of HFCS consumption will be a decrease in sucrose consumption. This continual shift to corn sweeteners will result in a reduction of domestic production of sugar and/or a reduction in imports of "raw sugar."

The U.S. population is concentrated in the Northeast, Midwest and California, whereas sucrose production is located in the West, Northern Great Plains, extreme South and Hawaii (Table 4). Beet sugar is refined and packaged under sanitary conditions at the site of production, whereas cane producers ship "raw sugar", which does not require sanitary shipment, to cane refiners near the site of consumption. The beet sugar producers will have difficulty competing with the domestic cane producers, imports of "raw sugar", and corn sweeteners, because of transportation cost to the eastern U.S. markets.

Table 4. Data on Caloric Sweeteners by State for 1980 and Comparison Between Overall Data for 1970 and 1980.

Region-State	Population	Sucrose Production	Sucrose Consumption	Corn HFCS (1)	Corn Other Sirups
	million	1,000 Short Tons			
Northeastern					
Maine	1.1		47.8	10.6	12.5
New Hampshire	0.9		39.1	8.7	10.2
Massachusetts	5.7		243.8	54.2	63.7
Rhode Island	0.9		36.0	8.0	9.4
Connecticut	3.1		132.1	29.4	34.5
New York	17.6		746.2	165.9	194.9
New Jersey	7.4		313.0	69.6	81.7
Pennsylvania	11.9		504.3	112.1	131.7
Vermont	0.5		21.7	4.8	5.7
Northcentral					
Ohio	10.8	42	458.9	102.0	119.8
Indiana	5.5		233.3	51.9	60.9
Illinois	11.4		485.3	107.9	126.7
Michigan	9.3	236	393.5	87.5	102.8
Wisconsin	4.7		200.0	44.5	52.2
Minnesota	4.1	445	173.3	38.5	45.3
Iowa	2.9		123.8	27.5	32.3
Missouri	4.9		209.0	46.5	54.6
North Dakota	0.7	252	27.7	6.2	7.2
South Dakota	0.7		29.3	6.5	7.7
Nebraska	1.6	222	66.7	14.8	17.4
Kansas	2.4	25	100.4	22.3	26.2
Southern					
Delaware	0.6		25.3	5.6	6.6
Maryland	4.2		179.2	39.8	46.8
District of Columbia	0.6		27.1	6.0	7.1
West Virginia	1.9		82.6	18.4	21.6
North Carolina	5.9		250.0	55.5	65.2
South Carolina	3.1		132.6	29.5	34.6
Georgia	5.5		232.2	51.6	60.7
Florida	9.7	1050	413.9	92.0	108.1
Kentucky	3.7		155.6	34.6	40.6
Tennessee	4.6		195.1	43.4	51.0
Alabama	3.9		165.3	36.7	43.2
Mississippi	2.5		107.1	23.8	28.0
Arkansas	2.3		97.1	21.6	25.4
Louisiana	4.2	470	178.7	39.7	46.7
Virginia	5.3		227.2	50.5	59.3
Oklahoma	3.0		128.6	28.6	33.6
Texas	14.2	129	604.7	134.5	157.9

Table 4 - Continued.

Region-State	Population	Sucrose Production	Sucrose Consumption	Corn HFCS (1)	Corn Other Sirups
	million	---------------- 1,000 Short Tons			----------------
Intermountain					
Montana	0.8	110	33.4	7.4	8.7
Idaho	0.9	407	40.1	8.9	10.5
Wyoming	0.5	128	20.0	4.4	5.2
Colorado	2.9	216	122.8	27.3	32.1
New Mexico	1.3		55.2	12.3	144.4
Arizona	2.7	26	115.5	25.7	30.2
Utah	1.5		62.1	13.8	16.2
Nevada	0.8		34.0	7.6	8.9
Far West					
Washington	4.1		175.5	39.0	45.8
Oregon	2.6	25	111.9	24.9	29.2
California	23.7	721	963.4	214.2	251.6
Alaska	0.4		17.0	3.8	4.4
Hawaii	1.0	1023	41.0	9.1	10.7
Totals 1980	226.5	5531	9,626.5	2,140.5	2,514.2
1970	203.3	5874	10,348.1	71.2	1,890.7
% Change	11.4	-5.8	-7.0	2906.3	33.0

(1) HFCS -- high fructose corn sirup.

It was noted earlier in this report that numerous processing facilities have closed during the last decade, and the trend is likely to continue as cost increase and prices remain unstable. Over one-half of the sugarbeet processing facilities currently operating were built before 1921 and some before 1900 and all are utilizing basic technology developed over 100 years ago. Processors have not made large investments in upgrading their plants and no new facilities are planned for the immediate future. There is a general sentiment in the industry that no new processing plants will be built without a major breakthrough in processing technology that would lower processing cost and increase extraction efficiency. In the immediate future, building a new facility with the best available technology would cost between 120-150 million dollars. Presently, there is a limited amount of processing technology research in progress by the public and private sectors. All processors are currently operating at full capacity, therefore, expansion is not possible without new facilities. The domestic sucrose industry is important in maintaining a supply of nutritive sweeteners that are needed in products where HFCS will not currently substitute.

Most sugar producer and user groups testified at the U.S. Senate and U.S. House of Representatives hearings on inclusion of sugar in the 1981 Farm Bill that a domestic sugar industry is a vital concern (3, 4, 7, 9, 10, 14). The groups did not agree as to the best policy, but most recognized that the United States should continue to produce sucrose since corn sweeteners cannot be used by all consumers in the sweetener market. To maintain a domestic sugarbeet and sugarcane industry, research and extension are needed to continue development of agricultural programs that increase the stability of the domestic industry. The size and distribution of the domestic industry will be determined by the market forces affecting production and distribution cost.

Future Projections Concerning the Sugar Crops Research Program

Alternative a. The domestic sugar industry will continue to decline and corn sweeteners will continue to increase. The S&E sugar crops research programs have undergone shifts in resource allocation and research areas over the last decade. These changes have not necessarily reflected the loss of processing capacity by both the sugarbeet and sugarcane industries. The continued loss of processing capacity indicates that S&E agencies should examine their sugar research programs and determine their future direction to meet changing practices and problems associated with the domestic industry.

Major problems of the domestic industry are high processing costs, obsolete equipment, small factories, and no improvement in extraction efficiency. S&E agencies could make a major contribution to the domestic sugar industry if new or improved processing technologies were developed in the next decade that would lower cost, use less energy, and improve extraction efficiency.

The breeding and agronomic research programs conducted by S&E agencies should also be examined. Presently, none of the major production areas have completely stopped sugar production. However, severe reductions have occurred in one or two areas and the trend is likely to continue. This trend indicates that S&E agencies should prepare for a redirection of resources in some production areas, consolidate research efforts in other locations, and improve the coordination of research programs between the State and Federal agencies. Improved coordination and elimination of duplicate programs between State and Federal laboratories would allow for maximum utilization of resources in the sugar crops research program.

The sugarbeet industry will probably experience a larger decline than the sugarcane industry because of processing cost, high energy demands, and its location in relation to markets. A reduction in acreage in any particular location should not cause a major increase in acreage of other crops. Sugarbeets are regarded as a minor crop in total acreage in any production area. However, sugarbeets have traditionally been a high value crop on a per acre basis and most alternative crops will not produce the same level of income to producers. Vegetables and/or other speciality crops would be an exception. In major corn or small grain production areas, producers will suffer a loss of income on a per acre basis if they stopping producing sugarbeets.

An ad hoc panel of scientists and administrators of S&E agencies should be established to set future goals and objectives of the S&E agencies research programs to meet the needs of the changing domestic sugar industry.

Alternative b. The domestic sugar industry will remain at its present size and distribution. Processing research is a priority area to be considered under this alternative so that the domestic industry will remain competitive with other sources of nutritive sweeteners. A large number of processing facilities must be upgraded over the next decade under this alternative to remain competitive. There are technologies that can be implemented to improve processing of sugar crops, e.g. reuse of low pressure steam and ion exchange systems for removal of sugar from molasses. However, research is needed to lower energy use, improve extraction efficiency, reduce loss of sugar in byproducts, and improve byproduct utilization.

S&E agencies should continue to stress development of superior sugarbeet germplasm for release to private industry and development of superior sugarcane cultivars. Development of specific agronomic and pest management strategies should be high priority areas in all sugar crops. Increased sugar recovery per ton of sugarcane or sugarbeets and sugar per acre are priority areas for continued research.

Improved coordination and elimination of duplicate programs should be a major objective under this alternative. S&E agencies should utilize their resources to maximize research and extension efforts in support of the domestic industry.

Alternative c. Sugar crop acreage will increase because of increased demand for sweeteners. This is not a likely alternative because current processing facilities are operating near capacity and additional acreage would require new processing facilities. New processing facilities are not economically feasible with current technology, cost of production, unstable prices, current yield levels of sugar crops, and the length of the processing period. Increased demand for sweeteners will likely be met by increased use of corn products, imports of "raw sugar," or noncaloric sweeteners. New processing technologies are needed before sugar crop acreages will increase significantly.

Alternative d. Sugar crop acreage will increase as a response to increased demand and/or shortage of liquid fuels. S&E agencies have established research programs to determine the potential energy yield on a per acre basis from sugar crops. The current programs are focused on breeding and production. Recent data indicates that maximum energy yields from sugarcane may be associated with high fiber types of sugar cane. The data indicates that potential yield of

alcohol from sugarbeets may be increased by breeding for total fermentable sugars and ignoring traditional processing qualities. Therefore, only minor modifications are needed in the breeding programs.

Research is needed on converting the biomass from sugar crops into a usable form of energy at competitive prices. Production of sugar crops for energy will not require modification in established agronomic practices utilized in production of these crops.

Energy production from sugar crops is not a likely alternative at this time because of conversion costs, availability of sugar crops on a year-round basis, and the energy input:output ratio.

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Appendixes

Appendix A.

Missions of the ARS units working on the sugar crops program by states.

Sugarbeets

Salinas, CA: (1) Develop new parental lines and hybrids of sugarbeet resistant to bolting, diseases, and nematodes; (2) improve sugarbeet germplasm through interspecific hybridization; (3) determine biology of virus, fungus, and bacterial disease in relationship to transmission, disease occurrence and pathology; (4) determine ultrastructural changes in sugarbeet diseases and in sugarbeet breakdown during postharvest transit and storage; (5) chemically and culturally reduce crop damage caused by nematodes; and (7) determine biology of nematodes in susceptible, tolerant, and immune plants.

Fort Collins, CO: (1) Develop genetic principles, effective breeding methods, and superior germplasm for improved sugar production, through (a) determining genetic control of quantitative sucrose yield components and translation of this information into more effective breeding methods, and (b) breeding for resistance to rhizoctonia root rot and cercospora leaf spot, and developing breeding lines useful as parents in hybrid varieties; (2) study the epidemiology and etiology of sugarbeet diseases by determining the factors that contribute to disease development and the interaction of pathogens with environment and cultural practices; (3) determine physiology and biochemical factors that affect the pre- and postharvest beet quality, sucrose content, and disease resistance, and the interrelationships of these factors with geneotype and environment; (4) develop more efficient use of herbicides for sequential applications to reduce crop losses due to weeds, and to minimize the effect of soil residues on subsequent crops; and (5) develop integrated systems of weed control in crop rotations including sugarbeet.

Kimberly, ID: (1) Reduce crop losses in sugarbeets by controlling or suppressing insect populations with insecticides, and by developing plant resistance to the sugarbeet root maggot; (2) determine optimum irrigation treatments for the production of fermentable sugars.

Beltsville, MD: Develop and release improved sugarbeet germplasm by effective screening for better pest resistance, improved quality characteristics, greater drought, cold, and salt tolerance, and more efficient harvesting and handling characteristics.

East Lansing, MI: (1) Develop new and improved breeding lines of sugarbeets; (2) develop and improve disease resistance screening techniques; (3) develop cultural, biological and chemical disease control methods; (4) monitor the occurrence of sugarbeet diseases and determine their causal agents; and (5) develop sugarbeet tissue culture techniques to regenerate plants from cells cultured *in vitro*, maintain suspension cultures for pathology and physiology studies, recover haploids and homozygous diploids, multiply shoot meristems *in vitro* and then root them, and preserve germplasm by storage of tissue.

Sidney, MT: (1) Evaluate the use of no-till and minimum tillage techniques to replace conventional seedbed preparation for sugarbeet production; and (2) determine nitrogen requirements under minimum tillage production.

Fargo, ND: (1) Develop sugarbeet breeding lines and experimental hybrids that possess a low respiration rate and/or resistance to storage rot pathogens, and develop breeding lines possessing resistance to the sugarbeet root maggot; (2) investigate the effects of different cultural practices on growth, harvest quality, sucrose yield, and quality deterioration of roots during storage; (3) refine methods of evaluating roots for respiration rate and resistance to storage rot pathogens; and (4) obtain new information of the biology and pathogenicity of important storage rot pathogens, especially *Phoma betae*.

Logan, UT: (1) Develop new and improved breeding lines of sugarbeet that combine high root yield, sucrose content, quality, pest resistance, and root storageability; (2) determine the morphological, physiological, and biochemical factors limiting or governing photosynthate partitioning, root growth, and sucrose accumulation; (3) develop new innovative seedling selection techniques and breeding methods for rapid, efficient improvement of sucrose production; (4) search for new sources of male sterility as a means of improving hybrid seed production; (5) utilize serological and histological methods to measure specific pathogenic effects on resistant and susceptible host plants and determine the host-vector-pathogen relationships relative to diseae control; (6) evaluate sugarbeet genotypes that maximize biomass production and have potential use in the development of alcohol for fuel.

Sugarcane

Belle Glade, FL: Design, construct, and perform field or laboratory experiments on improved components for planting, cleaning and harvesting recumbent sugarcane. The equipment and processes that are designed should (1) reduce manual tasks in planting and cutting sugarcane; (2) use minimum horsepower; (3) operate in unburned sugarcane; and (4) reduce the tops and leaf trash in sugarcane without damage to the mature stalks.

Canal Point, FL: (1) Produce sexual seed of recommended crosses and supply the seed to the three SEA-AR commercial sugarcane breeding programs at Houma, LA; Meridian, MS; and Canal Point, FL; (2) conduct a sugarcane variety development program for the Florida sugar industry; (3) conduct associated research on dieases, selection methods, and production practices; (4) maintain the World Collection of Sugarcane and Related Grasses for use by sugarcane breeding programs around the world; and (5) conduct research to provide the necessary control methdos for insect in Florida sugarcane fields.

Aiea, HI: (1) Develop new and improved cultural and management practices to increase plant and sugar yields, minimize production losses, improve quality attributes and efficiently conserve scarce resources and (2) develop new and improved breeding lines and varieties that combine high-yielding potential and favored quality characters with better pest resistance, drought-cold-salt tolerances, and adaptation of mechanized culture, harvesting and handling.

Baton Rouge, LA: Develop and evaluate under field conditions, water management systems for fine textured soils in warm, humid climates and the response of sugarcane to various management systems.

Houma, LA: (1) Develop new and improved breeding lines and varieties that combine high yielding potential and favored quality characters with better pest resistance, drought-cold-salt tolerance, and adaptation to mechanized culture, harvesting and handling; (2) develop new and improved cultural and management practices that increase sugar and sirup yields, minimize production losses, improve quality attributes and efficiently conserve scarce resources; and (3) develop better integrated pest management strategies and tactics for suppressing insects, weeds, and disease by investigating (a) insect, disease, and weed resistance in sugarcane cultivars, (b) cultural control practices, (c) biological agents for pest suppression, and (d) chemical pesticides.

New Orleans, LA: (1) Identify and analyze the various chemical constituents in plant products; (2) study the utilization of the constituents to properties of the end-products; and (3) study the fundamental chemistry and physics of processes employed in the manufacture of th end-products for agricultural commodities, especially cane sugar.

Beltsville, MD: (1) Perform quarantine inspection of sugarcane introductions and certify all shipments from Beltsville; (2) develop improved quarantine procedures; (3) develop methods for culture of RSD-associated bacterium; (4) characterize RSD, mosaic virus, and sugarcane smut diseases; (5) perform sweet sorghum crosses for sweet sorghum project; and (6) study and characterize sugarcane mosaic virus in sweet sorghum.

Weslaco, TX: Develop continuous pilot-plant procedures adaptable to factory production of sugar from sugarcane and sweet sorghum, and determine crop potential for biomass energy production.

Sweet Sorghum

Meridian, MS: (1) Breed, maintain, and increase productivity of improved sweet sorghum lines and varieties for sirup, sugar, and biomass, (2) breed, maintain, and increase productivity of sugarcane for sirup production, (3) maintain world collection of sweet sorghum germplasm; and (4) develop new and improved cultural and management practices that increase sirup, sugar, biomass yields, minimize production losses, improve quality attributes and efficiently conserve scarce resources.

Appendix B. Projects Reported to CRIS by SAES in 1978 or 1979 (1).

State	Title	Termination Date
Sugarbeets		
AR	Growth Regulators Effect on Seed Germination	1980
AR	Fungal Root Rot of Sugarbeets: Prediction, Using Infrared Thermmetry, and Control	1980
AR	Sugarbeet Management under Irrigated Conditions	1980
AR	An Epidemiological Model for the Prediction, Loss Assessment and Control of Root Diseases of Sugar-beet	1982
CA	Resistance to Western Yellows Virus in Sugarbeets	1978
CA	Assessment and Control of the Nutritional Status of Crop Plants	1982
CA	Aphid Transmission of Circulative and Propragative Plant Viruses	1985
CA	Economic Analysis of Alternative U.S. Sugar Policies	1981
CA	Integrative Physiology of Crop Production Systems	1980
CA	The Improvement of Sugar Beet Production Practices	1980
CA	Ecology, Biology, and Integrated Control of Insects and Mites Affecting Sugarbeet	1980
CA	Ecology of Beet Leafhopper in Changing Ecosystems of California	1980
ID	Nontoxic Control Agents for Plant Parasitic Nematodes of the Genus Heterodera	1981
CO	An Interregional Economic Analysis of the Beet Sugar Industry	1980
CO	A Model System for Evaluating Pesticide-Plant Pathogen Interactions in Predisposing Host Plants to Disease	1982
CO	Insect Pest Management Program for Sugarbeet	1983
CO	Effect of Soil and Crop Management on Growth of Sugarbeets	1984
CO	Ultrastructural Cytochemistry of Rhizoctonia Solani-Infected Beans and Sugarbeets	1980
CO	Research, Development, and Use of Nematode Pest Management Systems	1979
ID	Effect of Harvest and Handling Damage on Processing Quality of Sugarbeets	1981
ID	Sugarbeet Variety Evaluations in Idaho	1979
MN	Sugarbeet Production	1981
MT	Statewide Fertilizer and Related Soil Management Research Program	1980
MT	Improvement of Soil Fertility for Sugarbeet Production	1980
MT	Improvement of Cultural Methods for Sugarbeet Production in Eastern Montana	1979

Appendix B - Continued

State	Title	Termination Date
MT	Weed Control Investigations	1980
MT	Sugarbeet Varieties and Production	1980
MT	Soil Fertility, Plant Nutrition, and Fertilizer Use	1982
ND	Biology and Control of Sugarbeet Root Maggot	1982
ND	Effects of Management on Sugarbeet Production	1982
ND	Economics of Sugarbeet Production in the Red River Valley	1982
ND	Weed Control in Sugarbeets and Related Basic Problems	1983
NE	Bionomics and Management of Selected Insect Pests in the Nebraska Panhandle	1985
NE	Integrated Approaches to Management of Disease Caused by Soil-Borne Plant Pathogens on Field Crops	1984
NE	Principles and Practices of Weed Control for West Central Nebraska	1980
NE	Biology and Control of Insect Pests of Western Nebraska	1979
NE	Cultural and Nutrient Investigation for Irrigated Crops in Western Nebraska	1980
NE	Weed Control for Western Nebraska Crops and Conditions	1981
NM	Test of Adaptation and Cultural Practices for Crops of Potential Importance for the High Plains	1980
OH	Improvement of Sugarbeet Emergency and Stand	1979
OH	Rhizoctonia Crown Rot of Sugarbeets	1999
OH	Fertilizer Use of Sugarbeets	1980
OH	Weed Control of Sugarbeets	1978
OH	Ohio Sugarbeet Variety Performance Test	1984
OH	Integrated Approaches to Management of Disease Caused by Soil-Borne Plant Pathogens on Field Crops	1984
OR	Soil Management and Crop Rotation Effects on Crop Production	1985
TX	Management of Sugarbeets for the Texas High Plains	1980
UT	Control Mechanism for Photosynthate Partitioning within the Sugarbeet Root	1981
UT	Development of the Basic Parameters for Nematode Pest Management Decisions	1984
WA	The Epidemiology and Control of Fungus Pathogens of Mint and Sugarbeets	1980
WY	Biology and Control of Field Crop Insects	1980
WY	Energy and Soil Conservation Techniques for Establishment of Crops in Wyoming	1982
WY	Weed Control in Agronomic Crops	1983
WY	Role of Pesticide Application Methods and Climatic Factors in Sugarbeet	1978

Appendix B - Continued

State	Title	Termination Date
WY	Evaluation of Field Crops in Wyoming	1984
WY	Soil Management for Crop Nutrition in Wyoming	1984

Sugarcane and Sweet Sorghum

State	Title	Termination Date
FL	Development of Sugarcane Varieties for Florida	1982
FL	Microbial Agents and Their Use in Managing Insect Pests	1984
FL	Nutrition and Associated Cultural Practices for Sugarcane	1980
FL	Weed Control in Field and Forage Crops	1983
FL	Biomass Production and Composition of Sugarcane	1980
HI	Soil Water Properties, Spatial Variability and Implications in Soil Management	1984
HI	Trickle Irrigation to Improve Crop Production and Management	1983
HI	Water Use by Sugarcane	1980
HI	Economic Viability of Independent Sugarcane Growers on the Hilo Coast	1980
HI	Optimizing Micro-Element Nutrition of Sugarcane for Growth and Sugar Yields	1980
LA	Develop New Varieties of Sugarcane	1981
LA	Imported Fire Ant: Cultural Control and Effect on Hay Meadows; Interaction with Sugarcane Culture	1980
LA	Breeding and Selection of New Varieties of Sugarcane for the Louisiana Sugar Industry	1986
LA	Outfield Sugarcane Variety Trials	1980
LA	Soil Fertility and Nutrition Studies with Sugarcane in Louisiana	1980
LA	Control of Sugarcane Insect Pests	1979
LA	The Breeding Behavior of Yielding Ability and Associated Characteristics in Sugarcane	1983
LA	Effects of Cultural Practices on Yield and Other Plant Characteristics of Sugarcane	1985
LA	Evaluation of Unreleased Sugarcane Varieties to Mosaic, Ratoon Stunting Disease, and Other Diseases	1983
LA	Evaluation of New Sugarcanes to Seedpiece and Root Rots and Stubble Deterioration	1983
LA	Etiology and Pathology of Ratoon Stunting Disease	1981
LA	Biochemical and Physiology Components of Sugarcane Yield as Related to Genotype and Plant Growth Regulation	1984
LA	Drip Irrigation in Humid Climate	1980
LA	Reduction of Freeze Damage to Plants	1981

Appendix B - Continued

State	Title	Termination Date
LA	Evaluation of Louisiana Agricultural By-Products as Potential Feedstuff for Dairy Cattle	1982
LA	Early Establishment of Millable Stalk Population in Sugarcane	1984
LA	Use of Chemical Herbicides for Broadleaved Weeds and Grass Control in Louisiana Sugarcane	1981
LA	Factors Affecting Mechanical Harvesting and Handling Efficiency of High Population Sugarcane	1981
LA	Economic Study of Vertically Integrated Sugarcane and Raw Sugar Production in Louisiana	1981
LA	Economic Study of Machinery Complements and Alternative Production Practices for Sugarcane Farms	1981
LA	Insect Physiology, Biochemistry, and Behavior	1981
LA	Investigations on Sugarcane Smut	1980
LA	Sugarcane and Sweet Sorghum as a Renewable Biomass Energy Resource	1982
LA	Pest Management of Sugarcane Insects	1983
LA	Sweet Sorghum for Sugar Production	1980
PR	Census of Sugarcane Varieties in Puerto Rico	1999
PR	Survey of Sugarcane Diseases and Insects	1978
PR	Optimizing Mechanical Harvesting Systems	1977
PR	Standards and Field Equipment for Sugarcane Production	1978
PR	Fertilizer Requirements of Sugarcane	1978
PR	Expansion of the Saccharum Genetic Base with Growth-Regulatory Chemicals	1981
PR	Production of Sugarcane and Tropical Grasses as Renewable Energy Source	1981
PR	Sugarcane Breeding	1980
PR	Plant Germplasm - Its Introduction, Maintenance and Evaluation	1980
PR	Physiological Factors Affecting the Sucrose Content of Sugarcane	1981
PR	Control of Weeds in Crops of Economic Value	1980
PR	Evaluation of Selected Insect Control Practices in Crops of Economic Importance	1980
PR	The Biology of Selected Insects of Economic Importance in Puerto Rico	1980
PR	Insect Populations Dynamics and Economic Threshold Levels of Crop Insects Important in Puerto Rico	1980
PR	Factors Affecting Fermentation Efficiency of Molasses by Yeasts and Effects on Quality of Rums	1983
PR	Evaluation of Fungicides for Controlling Plant Diseases	1979
PR	Nature and Extent of Variation in Root-Knot and Cyst Nematodes	1980
PR	Root Diseases of Sugarcane	1980

Appendix B - Continued

State	Title	Termination Date
TX	Mechanized Harvesting of Sugarcane and Sweet Sorghum	1980
TX	Biology, Ecology and Control of Insect Pests of Sugar and Energy Crops	1980
TX	Viruses/83 S Diseases of Sugarcane, Sweet Sorghum and Related Species	1980
TX	Sugar Crop Research in the Lower Rio Grande Valley of Texas	1981
TX	Sugar/Energy Crop Physiology	1985
TX	Crop Response to Soil Fertility and Salinity Management in Subtropical South Texas	1984

(1) CRIS -- Current Research Information Service
SAES -- State Agricultural Experiment Station